Habitat Inventory and Assessment of Juanita Creek in 2000

April 2002

City of Kirkland Washington

King County

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Report to:

City of Kirkland

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SUMMARY

Declining stocks of native salmon, increasing urbanization, and the listing of the Puget Sound chinook evolutionarily significant unit (ESU) as threatened under the Endangered Species Act have intensified interest in assessing instream habitat conditions in the City of Kirkland and King County streams. Little current information about the habitat condition of Juanita Creek was available. The King Conservation District provided funding to Kirkland and King County to complete this assessment.

In August of 2000, habitat on Juanita Creek was assessed using methods derived from standard assessment protocols. The goals of the habitat assessment project for Juanita Creek were threefold: (1) characterize instream and riparian habitat quality–primarily for salmonids; (2) establish a baseline for future evaluation of trends in habitat quality and watershed function; and (3) provide information for process of prioritizing areas for restoration and preservation. Stream segments were defined by using the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) stream segment delineation, which is based on stream gradient and confinement categories.

The results of the habitat assessments indicate that channel and habitat structure of a number of the segments of Juanita Creek are degraded relative to values from published “properly functioning conditions” for the Puget Sound or the Pacific Northwest region. For example, riparian vegetation quality and large woody debris (LWD) frequencies are below the prescribed properly functioning or natural conditions in all segments. Pools are of low quality in most segments. This decreased quality of slow water rearing habitat may limit juvenile carrying capacity as well as hinder upstream migration by adult salmon.

These data suggest that processes creating natural habitat structure are likely to be altered from natural conditions. Previous analysis of basin land cover reveals little forested cover remaining and high percentages of impervious surfaces, which are changes that have been shown to alter the basin hydrologic regime. These increases in the rate at which stormwater runoff enters the stream increases erosion rates and lead to destabilization of channel morphology. Riparian vegetation seldom resembled natural conditions and was nearly completely depleted of sources of high quality, coniferous LWD. Dominant riparian vegetation included ornamental trees and shrubs and lawns associated with landscaping, native shrubs, and deciduous forest. As a result, LWD frequencies were low in most segments of Juanita Creek. The low amounts of instream LWD are likely responsible for the low pool frequency.

Data collected during assessment of Juanita Creek provide important baseline information for monitoring changes in habitat quality, and for any restoration projects that might occur in the basins. Data contained herein may be used for an analysis of factors that may be limiting productivity of salmonid species in this basin. The collected data may also be analyzed at a finer spatial scale to inform project planning at more localized sites or among basins for regional project planning. Land use planning, transportation planning, and stormwater management planning in these basins may also benefit from these data. Water Resource Inventory Area 8 (WRIA 8, Lake Washington Area) reconnaissance assessments and watershed planning for salmonid species recovery have utilized these data and will likely continue to do so.

INTRODUCTION

Over the past century, the historic range of Pacific salmon in the Pacific Northwest (PNW) has been reduced by nearly 50% (Nehlsen et al. 1991). The resulting reduction in salmonid abundance and diversity has led to the listing of several salmon stocks in the PNW under the Federal Endangered Species Act (ESA). There is no single cause for this decline, but significant contributors are human impacts on the aquatic ecosystems that support salmon populations (NRC 1996). Activities such as timber harvest, mining, agriculture, grazing, dams, fishing, hatcheries, and urbanization have all contributed to the "salmon problem." Urbanization (residential, commercial, and industrial) has been especially hard on small streams in the lowland ecoregions of the PNW (May et al. 1997). These small streams provide critical habitat for all freshwater life stages of salmonids (Williams et al. 1975).

The objective of the stream habitat assessment implemented by the City of Kirkland and King County in 2000 and described in this report was to quantify and assess the quality of the instream and riparian conditions that contribute to salmonid habitat. Stream habitat evaluation is a core element of several recently implemented regional programs. The Water Resource Inventory Area 8 (WRIA 8, Greater Lake Washington Watershed) technical committee is compiling stream habitat information as part of the salmon recovery planning process, which will result in identification of areas that require stream habitat restoration and preservation. The stream habitat assessment data discussed in this report have been incorporated into the "Salmon and Steelhead Habitat Limiting Factors. Water Resource Inventory Area 8" dated 2001 (Kerwin 2001). This report will provide information about Juanita Creek to benefit these and other projects and also supports other land use planning and Sensitive Areas regulation efforts.

Stream habitat loss and degradation are often cited as important limiting factors to salmon (Salo and Cundy 1987, Groot and Margolis 1991, Nehlsen et al. 1991, NRC 1996). High-quality rearing habitat is critical for the survival of juvenile salmonids from emergence to smolt migration. Adequate total pool area and depth along with sufficient hiding and thermal cover are necessary for successful salmonid rearing (Konopacky 1984, (Bjornn and Reiser 1991). Juvenile chinook, for example, use deep pools with good cover for freshwater rearing when they have emerged from stream gravels and before smoltification (Bjornn and Reiser 1991). Salmonids often shift their habitat preferences seasonally, primarily as a result of changes in flow and usable stream area. For example, juvenile coho prefer off-channel, backwater, or wetland pools during the winter, and show a preference for main-channel pools formed by large woody debris (LWD) in the summer months (Nawa et al. 1990, Nickelson et al. 1992, Peterson et al. 1992). In addition, adult chinook require deep staging or holding pools for their upstream migration and spawning (Giger 1973).

Human activities in the watershed can have detrimental effects on salmonid spawning habitat (Bisson et al. 1992). Pool frequency and quality decreases with increasing urbanization, in addition riffles tend to be replaced with glide habitat in channelized reaches (May 1997). Some studies indicate that the optimum pool to riffle ratio for salmonid production and over-winter survival is approximately 1:1 (Nickelson et al. 1992). On the other hand, Montgomery et al. (1999) found that chinook and coho redd frequency increased with decreasing pool spacing (i.e., increased pool frequency) in tributaries to the Skagit River. Streambed substrate is also critical to spawning success, incubation, and survival to emergence for salmonids. Each salmonid species has a specific preference for spawning habitat conditions (Kondolf and Wolman 1993), but all salmonids require spawning gravels that are highly permeable and well-oxygenated (McNeil 1966, Chapman 1988, Crisp and Carling 1989). Human activities in the watershed may contribute to sediment deposition in the interstitial spaces of spawning gravels by increasing over-land flow (including runoff) and stream bank erosion. This sediment may suffocate biota reliant on well-oxygenated intragravel flow (Hartman and Brown 1987).

Large woody debris performs numerous instream functions contributing to the formation of high quality aquatic habitat. Large woody debris is a key component for maintaining a high degree of habitat complexity and spatial heterogeneity in streams (Maser et al. 1988). In addition, LWD maintains the hydraulic stability of critical instream habitat features, especially pools (Bilby and Ward 1991). High-flow refuge for salmonids is provided by LWD, which dissipates hydraulic energy during peak flows (Bilby 1984). In addition, LWD stabilizes streambeds by minimizing scour and provides excellent cover and habitat diversity for salmonids (Harmon et al. 1986). If LWD is absent or scarce in the channel, stream morphology shifts away from the characteristic pool-riffle habitat to a more simplified, glide-dominant channel form, with a subsequent decrease in available pool rearing habitat.

Riparian forests play a critical role in the control of stream channel morphology because they stabilize the active floodplain and are the primary source of LWD. These "biophysical" interactions are particularly important to PNW stream ecosystems (Rot 1995). Riparian forest composition can determine the longevity and function of LWD in the channel. Large woody debris derived from conifers, especially western red cedar (*Thuja plicata),* tends to be larger than that from deciduous species, thus reducing the chance of being washed downstream. Large woody debris from conifers is also significantly more resistant to decay. This increased resistance results in increased longevity of instream structural components (Harmon et al. 1986). High riparian integrity is characterized by a large proportion of coniferous tree species, a wide buffer between the stream and any riparian development, and few spatial breaks (May and Horner 2000).

Modifications to natural land cover and the drainage network that result from urbanization change the hydrologic regime of the basin land-cover (Horner and May 1999) (Figure 1)). Under natural land-cover conditions in the PNW most stormwater infiltrates, and stormwater runoff is

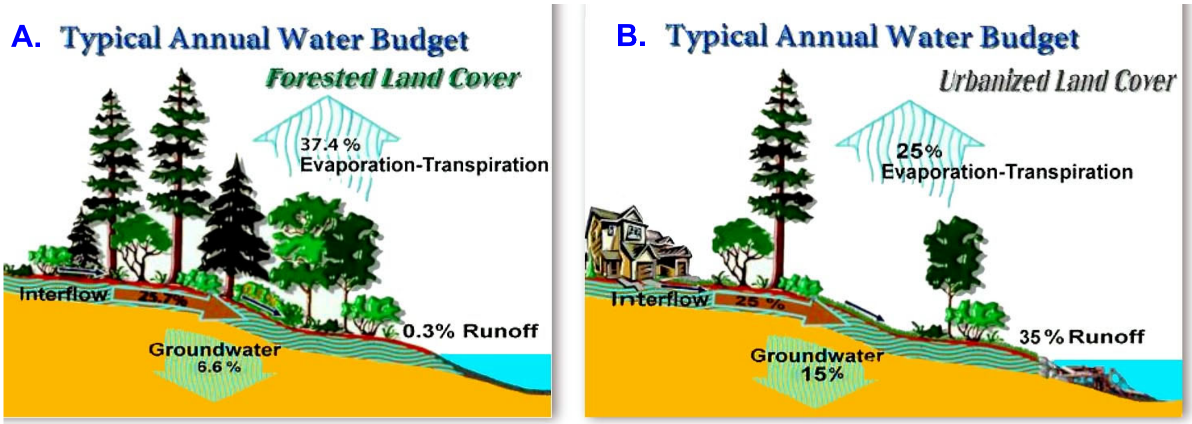

Figure 1. Typical annual water budget in watersheds with (A) forested land cover and (B) urbanized land-cover.

produced only during very large storm events (Booth 1991). As impervious surface increases with urbanization, the sub-surface dominated hydrologic regime created by stormwater infiltration shifts to one dominated by surface runoff. Urban development also adds numerous artificial channels to the natural stream system. The most common of these artificial channels are road-crossings (along with roadside drainage-ditches) that act as conduits for surface runoff and stormwater outfalls. Little or no infiltration or storage is associated with these artificial stormwater routing systems and as a result the runoff volume is dramatically increased.

In August of 2000, the City of Kirkland and King County conducted habitat assessments of Juanita Creek using the methods described herein. The goals of the habitat assessment project for Juanita Creek were threefold: (1) characterize instream and riparian habitat quality–primarily for salmonids; (2) establish a baseline for future evaluation of trends in habitat quality and watershed function; and (3) inform the process of prioritizing areas for restoration and preservation. This report describes how the City of Kirkland and King County characterized the stream and established baseline data for future monitoring projects and identification of priority restoration areas.

JUANITA CREEK

Juanita Creek is located within northeastern King County, Washington State. The Juanita Creek basin watershed covers approximately 6.6 mi^2 (17.14 km^2), and extends north to Simonds Road, south to NE 116th Street, east to 132nd NE, and west to 84th Avenue NE (Figure 4).

The climate and rainfall patterns in King County are typical of the Puget Sound Lowland (PSL) Ecoregion, with about 75% of the annual precipitation (average 38 inches annually) falling during the winter rainy season from October through April. Most precipitation is in the form of rain, with little snowfall.

The geology and soil structure of Juanita Creek Basin has been determined largely by the Vashon period of the Fraser glaciation about 15,000 years ago. The predominant surficial geology in the watershed is advance and recessional outwash deposits with some glacial till (King County 2001). The principal Soil Conservation Service (SCS) soil group within King County is classified as the Alderwood series (SCS hydrological soil group C), which is the most common soil type throughout the western part of the county. Hydrological soil group C is characterized by moderately high runoff potential (King County 1990).

The mainstem of Juanita Creek originates east of Interstate 405, and flows west and south entering the northeast end of Lake Washington on the west side of Juanita Beach Park. There are four main tributaries flowing into Juanita Creek: Simonds Tributary, (upper west), an unnamed lower west tributary, Totem Lake Tributary (lower east), and Tributary #238 (upper east). Areas around Juanita Creek are modified by residential and commercial development. From Juanita Drive to NE 124th Street, Juanita Creek flows through a highly developed urban area, containing multi-family housing developments and a professional center. From NE 124th Street to NE 132nd Street, Juanita Creek flows through both single and multi-family housing. Upstream of NE 132nd Street, the creek flows through the grounds of a psychiatric hospital, a rehabilitation clinic, and a school, as well as Edith Moulton Park, and single family housing.

The Simonds Tributary (upper west) to Juanita Creek joins the mainstem at NE 137th Place. The lower west tributary enters the mainstem of Juanita Creek from a culvert at NE 124th Street. This tributary is primarily made up of stormwater from single family housing, originating from a highly developed plateau further west (The Watershed Company 1998). Tributary #238 (upper east) originates north of NE 140th Street. It flows southwest to an in-stream pond near NE 132nd Street, then flows northwest and enters the mainstem of Juanita Creek near 108th Avenue NE. The Totem Lake Tributary (lower east) originates from Totem Lake, and flows through culverts under many roadways and Interstate 405. Downstream from Interstate 405, Totem Lake tributary flows through commercial businesses, Juanita High School, and a mix of single and multi-family residential housing, before entering the mainstem of Juanita Creek at a culvert outfall at 102nd Avenue NE and NE 129th Place.

The area was once almost completely forested with Douglas-fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), and red alder (*Alnus rubra*) (Franklin and Dyrness 1988). Repeated logging cycles beginning in the late-1800s, followed by residential and commercial development, especially since the mid-1960s, has reduced the forested land to a fraction of the original area (approximately 12%) (May, et al. 1997).

A 1956 review of conditions in Juanita Creek mentions that a few silver salmon (also called coho salmon, *Onchorhynchus kitsch*), silver trout (also called kokanee, *O. nerka),* and occasional cutthroat trout (*O. clarki)* are found in Juanita Creek (Ajwani 1956). In addition, in an overview of salmonid distribution in Washington streams, Williams (1975) noted that coho and sockeye salmon were found in Juanita Creek. In 2000, volunteer salmonwatchers observed small numbers of sockeye salmon and kokanee in the Juanita Creek basin (Vanderhoof 2001b).

METHODS

Stream habitat assessment methods for PNW streams abound (e.g. Overton et al. 1997, Pleus and Schuett-Hames 1998, Barbour et al. 1999). Many agencies in the region have developed their own protocols that use unique suites of channel features and channel feature definitions for the assessments. The habitat assessment protocol used here differs from others in that it incorporates a variety of methods used by local agencies. We have attempted to take into account the utility of each of these protocols as evaluated by Scholz and Booth (1998)In particular, methods were borrowed from the Timber, Fish, and Wildlife (TFW) Ambient Monitoring Manual, as well as a suite of other state, federal, and local protocols. The stream assessment protocol is described in detail in Appendix B.

Field Methods

The mainstem of Juanita Creek was assessed from its mouth at Lake Washington to the upper reaches just upstream of I-405. Survey segments were identified using breaks already defined by the Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP) (Figure 1, Appendix A). These segment breaks were determined using TFW methodology and gradient and confinement categories described in Pleus and Shuett-Hames (1998). The segments ranged from 0.55 to 1.34 kilometers long. At least 25% of each segment was assessed and assumed to be a representative sample, as determined by May, et al. (1997).

Reach Characterization

Riparian condition, land use, bank condition, and bankfull width and depth were measured and noted approximately every 25 meters in straight riffle habitats The intervening lengths between measurements at riffle habitat units are referred to as reaches. The following sub-sections provide descriptions of the measurements conducted at each riffle habitat.

Riparian Condition– Riparian vegetation composition was visually estimated for each 25 meters of stream length. Dominant riparian vegetation categories were described for the right and left banks using the following categories:

- Forest (greater than 6 m in height): coniferous, deciduous, or mixed
- Shrubs and/or vines
- Tall herbaceous (e.g., unmowed field)
- Short herbaceous (e.g., mowed grass, pasture)
- Impervious (e.g., buildings, roads, asphalt, etc.)
- Residential landscaped (mowed lawn with ornamental shrubs/trees)

Presence of invasive plant species was also noted.

Bank Condition– Bank stability was determined at every riffle on each bank using a method modified from Booth (1994). The following categories were used:

- **Stable**: vegetated or low bars to level of low flow, or stabilizing features (rootwads, vegetation, etc.).
- **Unstable**: signs of imminent erosion, or less than 50% vegetative cover.
- **Armored**: artificial bank protection of any kind (rip rap, wire mesh, etc.)

Riparian vegetation, bank condition, and canopy cover were summarized over the length of each stream segment. Weighted means of these reach scale data were calculated by summing together reach lengths represented by a parameter category then dividing this total length by the total number of meters surveyed in the segment. Right and left bank data were combined to determine the percentage of the segments falling into each data category.

Bank full width and depth– Bank full width and depth were measured at each riffle habitat. Bank full discharge occurs when the water just fills the channel. The field indicators of bank full dimensions included: the top of point bars, the lower limit of perennial vegetation, change in slope, bank undercuts, and stain lines. Bank full width is the width between these field indicators on each bank. Bank full depth is the average depth of water at bank full stage.

Instream Habitat Inventory

The habitat assessment included in-channel measurements of aquatic habitat units and an inventory of large woody debris. Aquatic habitat units were identified as pools, riffles, or other (see definitions below). In pool habitats, maximum depth and pool tail-crest depths were recorded, as well as four thalweg depths. Residual pool depth was calculated from the maximum and pool tail-crest depths (Figure 2). A Pool Quality Index (PQI) score was determined for each pool using a rating system modified from Platts et al. (1983). Pools received a higher rating if they were deep and large in relation to the size of the channel, and had additional features that provided cover for fish such as woody debris, overhanging vegetation, or undercut banks.

Instream measurements-- Habitat units were defined as:

Pool: Areas where scouring water has carved out a non-uniform depression in the channel bed or where water has been dammed. Slow water, with a width at least 1/2 of the wetted channel width and 20 cm minimum residual pool depth (Figure 3).

Riffle: Swiftly flowing, turbulent water with hydraulic jumps (white-water); some partially exposed substrate; substrate cobble and/or boulder dominated.

Other: Includes non-turbulent water habitat types such as **Glides**–wide, uniform channel volume, no thalweg, low to moderate water velocity, and little surface agitation, and **Runs**–deep and fast with defined thalweg and little surface agitation (definitions from Overton et al. 1997).

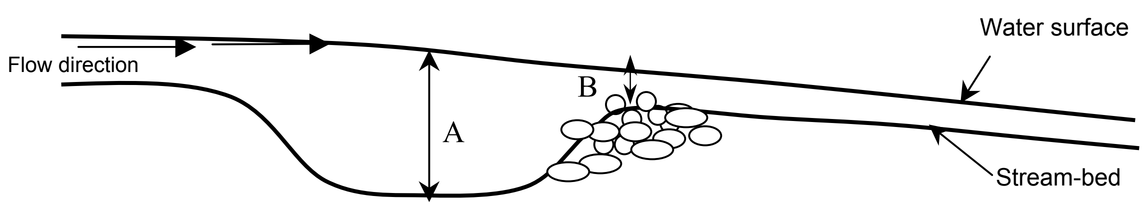

Figure 2. Measuring residual pool depth. The deepest point of the pool (A) minus the depth at the hydraulic control of the pool (B) is the residual pool depth. The hydraulic control has been described as where the last trickle of water would run out if the water were "turned off."

The frequency of each parameter was calculated for each segment (the number of times occurred standardized by length of stream inventoried) and compared to published frequency values from natural conditions for this area. The methodology for evaluating these parameters is outlined below.

Riffle habitat in each stream segment was quantified by calculating the surface area of wetted stream channel classified as riffles. This number was used to calculated the percentage total stream habitat classified as riffle habitat. Because an equal proportion of pool and riffle habitat is often considered optimum, the riffle fraction should be from 40% to 60% (Peterson et al. 1992).

Pool habitat in each stream was quantified by calculating the surface area of wetted stream channel classified as pools. The percentage of total stream habitat classified as pools was also calculated. Target conditions for pool frequency have been proposed by a number of authors. Peterson et al. (1992) suggest that pools should comprise 50%, by area, in streams with less than a 3% gradient. Greater than 40% cover, by surface area has also been recommended for streams with a 2% to 5%

gradient (Washington Fish and Game Commission 1997, Washington Forest Practices Board 1997). The National Marine Fisheries Service (NMFS) Matrix of Pathways and Indicators (NOAA 1996) suggests that 30 pools/km for a stream, such as Juanita Creek that is 6 m wide indicate "properly functioning conditions" for purposes of implementing the Federal Endangered Species Act (ESA).

Large Woody Debris (LWD)– Large woody debris was defined as logs at least 2 meters (6 feet) in length and at least 15 cm (6 in) in diameter (Peterson et al. 1992), or rootwads of any size. All pieces of wood within the bankfull width and spanning the channel were counted. The length and diameter of each piece of LWD was measured and recorded in the habitat unit it occupied. The number of LWD pieces in a debris jam (DJ) was determined and the volume of the DJ (including the small pieces) was estimated from three dimensions: L x W x D.

The frequency of LWD occurrence was calculated for each segment and compared to published values from PNW natural conditions. Large woody debris frequency was compared to published frequency ranges in natural forested systems of the PNW. The low end of the natural range in several studies was 150 pieces/km (a range of 150-460 in Murphy and Koski 1989, a range of 150-400 in Ralph et al. 1994, and a range of 140-670 for streams of similar size and gradient in Beechie and Sibley 1997). Especially large pieces of LWD initiate the formation of stable woody debris jams (Naiman et al. 2000). The NMFS Matrix of Pathways and Indicators suggests 50 pieces/km that are at least 60 cm wide by 15 m long indicate "properly functioning conditions" (NOAA 1996). Although NMFS did not categorize this size class as "key pieces," the large size range is comparable to the Washington State Forest Practices Board's Watershed Analysis Manual (1997) and Washington Department of Fish and Wildlife's (WDFW) Wild Salmonid Policy (1997) key piece size standard of 0.55 m diameter and 10 m in length for streams with a 6-10 m bankfull width. The Timber Fish and Wildlife (TFW) key piece criteria is based on a volume calculation that allows variable diameters and lengths (Schuett-Hames et al. 1999). The number of "large" diameter pieces was determined by counting all pieces of wood that met a minimum 50 cm diameter.

Tributaries, Wetlands, Side Channels, and Pipes

Notes were made on tributaries, wetlands, and side channels entering or adjacent to the stream, and location, size, and function of pipes (e.g., culverts, intakes). Notes were also taken to further describe the habitat quality, species identification, and presence of fish and wildlife. In addition, any obvious problems or concerns such as point of discharge or withdrawal for each reach were also described. Opportunity and/or need for protection or restoration projects were also noted.

Biology

Notes were made on the presence of juvenile and/or adult fish, freshwater mussels, amphibians and other biota. Juvenile salmonids, however, were not usually identified to species, although numbers or abundance was approximated. The reader should take into account that these are observations based on field notes and only represent conditions at the time of the assessment, and not a formal quantitative assessment of fish abundance. Moreover, it should be noted that the lack of an observation does not imply absence of a species from these sites.

Sediment Quality

Field notes regarding sediment quality were recorded for each segment. These remarks were either included in summary remarks about the segment or observations of specific locations.

Photographs

Photographs depicting the general nature of each assessed stream segment, as well as notable features were taken as the surveyors proceeded upstream. Representative photos will be included in this report to illustrate typical reaches or points of interest in each segment.

Water Quality

Water quality monitoring can reveal problems that may affect instream habitat quality. During this habitat assessment, limited water quality monitoring was performed on samples from Juanita Creek. These results will be compared with previous and future monitoring data.

Water quality was monitored at five total locations in segments 1, 2 and 3 (Figure 3). A HACH Sension156 Portable Multiparameter Meter was used to measure electrical conductivity, pH, temperature, and dissolved oxygen. Conductivity, pH, and temperature were measured from samples obtained on the afternoon of 10/06/2000. After recalibration of the dissolved oxygen meter, DO and temperature was measured from samples obtained on 11/14/2000. Two samples at each location were measured and the results were averaged.

Analysis

As previously mentioned, summarized instream and riparian values for each stream segment were compared to published values representing natural conditions or values that were determined to indicate naturally functioning conditions.

Matrix of Pathways and Indicators

In an effort to identify parameters indicative of ecosystem processes functioning in a manner that will maintain stable and healthy streams (for anadromous salmonid populations), [NMFS \,1996 #16] developed the "Matrix of Pathways and Indicators" as an evaluation tool (Appendix C). This matrix presents a number of environmental parameters important to production and survival of anadromous fishes and sets three condition levels for each parameter: (1) properly functioning, (2) at risk, and (3) not properly functioning. This matrix was also used by the WRIA 8 technical committee as a tool to aid in evaluating stream conditions within the PSL Ecoregion. If the data collected in these assessments could be compared with the NMFS matrix parameters, the results were presented with the matrix target conditions.

Quality Control

Two training sessions were held to prepare staff for the field survey season and assure accurate and precise data. A classroom session was held to discuss assessment protocols and the specific objectives of the habitat assessment. A second session was held in the field to provide surveyors with hands-on training in the use of the protocols and to provide surveyors with the opportunity to identify any questions or concerns with the methodology prior to the actual survey of Juanita Creek.

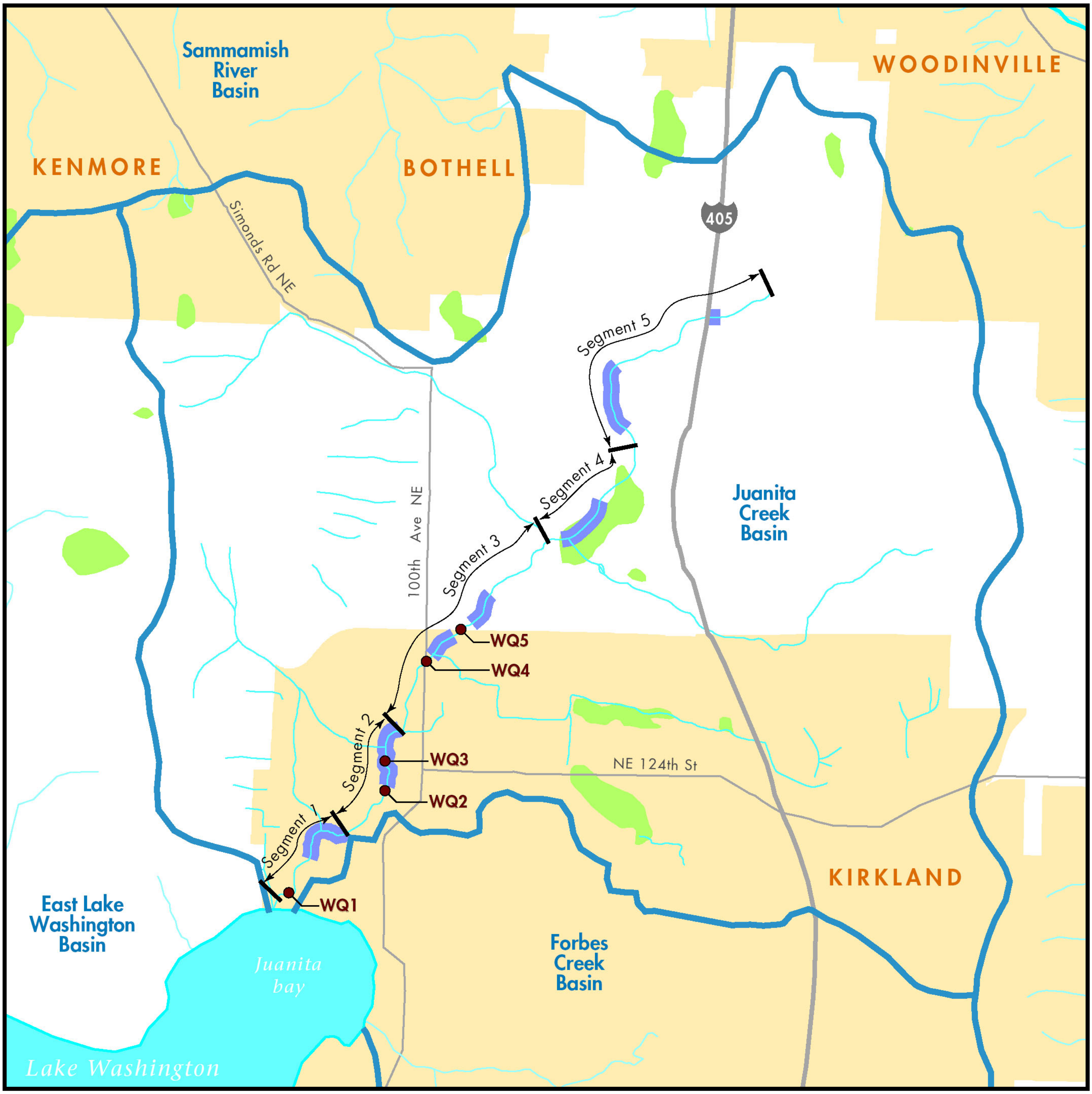

Figure 3

JUANITA CREEK HABITAT ASSESSMENT 2000

Basin Boundary
Stream
Lake
Wetland
Incorporated Area
WQ1 Water Quality Sampling Site
Assessed Reach
Assessment Segment

N

0 1/4 1/2 Mile

Map produced by:
DNRP GIS and Visual
Communications & Web Units.

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RESULTS

Data from the habitat assessments are summarized for each stream segment. Data summaries are presented in bulleted lists, and readers will find additional, more detailed data in the tables.

The Juanita Creek assessments began where Juanita Creek enters Lake Washington, and ended approximately 100 m upstream of I-405. An average of 35% of each segment (range: 27%-48%) was surveyed (Table 1, Figure 3). (For a complete description of the start and ending locations of the assessed reaches, see Appendix A.)

Table 1. Juanita Creek SSHIAP Segment Descriptions

Segment Number	Description	Length (km)	Length Surveyed (km)	Percent Surveyed	SSHIAP Gradient/ Confinement Category*
1	Mouth to 1st RR† tributary (near 1st crossing of 120th)	0.55	0.204	37	0-1 %, U
2	Ends just d.s. ‡ of 126th St. crossing.	0.85	0.412	48	0-1 %, U
3	Ends at confluence with 2nd RR tributary (near 108th)	1.34	0.453	34	1-2 %, U
4	Ends just d.s. of 141st.	0.79	0.215	27	1-2 %, U
5	To approximately 100 m u.s. ‡ of I-405	1.34	0.498	37	2-4 %, U

Segments are contiguous–one segment starts where the previous segment ends.

* Segment breaks coincide with SSHIAP breaks. U is unconfined, floodplain greater than 4X the channel width.

† RR is river right

‡ d.s. is downstream, u.s is upstream.

Data Overview

A summary of bank stability, bankfull width to depth ratios, riparian forest coverage, LWD frequency, and pool quality data is presented and these data are compared to natural, or NMFS "properly functioning conditions" values in Table 2 (see page 8 for a explanation of properly functioning conditions. Data which could be compared to literature or NMFS properly functioning conditions standards either did not meet natural, or properly functioning condition levels or fell in the NMFS "at risk" category. The percentage of stream banks rated stable in each segment ranged from 43 to 90%. Riparian forest cover, estimated visually from the stream channel, ranged from 21 to 72%. Bankfull width to depth ratios ranged from 3:1 to 10:1. The frequency of LWD in all of the segments was below natural frequencies (Murphy and Koski 1989, Ralph et al. 1994). Although the percentage of riparian forest cover in the upper segments was high, LWD frequencies remained low in all segments. The frequency of pool habitat was mostly higher than values suggested by NMFS' "properly functioning conditions," which is 35/km for Juanita Creek (NOAA 1996). A suggested optimal ratio of pool to riffle habitat is 1:1 (Peterson et al. 1992), suggesting that 40-60% by area for each habitat type is a target condition. Although segments 1 and 3 have 40-60% pool and riffle habitat, the mean pool quality for each of these segments is low. Segments 2, 4, and 5 do not meet the percent area criteria, but do meet NMFS frequency criteria, which indicates that the pools that were present in these segments were generally small.

Table 2. A data overview of Juanita Creek segments, that compares the study data with published values from natural conditions, or NMFS matrix of properly functioning conditions (pfc).

	Bank stability	**BFW/BFD Ratios****	**Forested Riparian vegetation‡**	**LWD frequency**	**Pool frequency**	**Pool quality**
Data standard	> 90% stable*	< 10:1	>80% intact, adequate source of LWD*	150 pieces/km†	35 pools/km*	> 1 m deep*
Segment Number						
1	43%, not pfc.	6:1, pfc.	21%, not pfc.	12, not nl. †	39, at risk	1 > 1m, not pfc.
2	68%, not pfc.	3:1, pfc.	44%, not pfc.	29, not nl.	44, at risk	0, not pfc.
3	90%, at risk	10:1, pfc.	72%, not pfc.	29, not nl.	42, at risk	0, not pfc.
4	75%, not pfc.	4:1, pfc.	62%, not pfc.	55, not nl.	46, at risk	0, not pfc.
5	73%, not pfc.	6:1, pfc.	71%, not pfc.	23, not nl.	28, not pfc.	1, not pfc.

** Bankfull Width to Depth ratios

‡ the data compared with the standard 'intact' forest, was total forested reaches, the majority of which was deciduous along Juanita Creek. It is unlikely that deciduous riparian vegetation would be considered a significant part of an intact riparian corridor.

* pfc.—properly functioning conditions, see Appendix B for explanation of criteria (NOAA 1996).

† nl.–natural levels, multiple references: a range of 150-460/km in Murphy and Koski 1989, a range of 150-400/km in Ralph et al. 1994, and 140-670/km for streams of similar size and gradient calculated from Beechie and Sibley 1997.

Riparian Vegetation

The riparian corridor of Juanita Creek is fragmented, with a maximum of 72% forest coverage found in segment 3. Very little of this remaining riparian forest is coniferous, which suggests that adequate long lasting LWD are not present in this stream ecosystem.

- The riparian corridor of Juanita Creek segments was generally increasingly forested (21%-72%) as one moved upstream
- The riparian corridor of segment 1 was classified as only 21% forested, entirely by deciduous tree species. Most riparian cover in this segment was classified as tall, herbaceous (Table 3, Figure 4).
- The riparian corridor of segment 2 was classified as 44% forested, primarily by deciduous species. The second most predominant vegetation class was shrubs.
- Segments 1-4 had very little of the riparian corridor forested by coniferous species (0-9%).
- A substantial coniferous component was present in segment 5 (41%).
- Blackberry (*R. discolor* or *R. laciniatus*) was present in all segments, and dominant in many reaches (Table 4).

Table 3. Riparian landcover on Juanita Creek, numbers are percentages of the total assessed segment length.

Segment	Tot. Forested	Forest. Decid.	Forest. Mixed	Forest. Conif.	Landscaped	Imperv.	Herb. Short	Herb. Tall	Shrub
1	21	21	--	--	--	--	7	57	14
2	44	39	4	4	--	--	9	11	33
3	72	58	5	9	4	--	--	9	15
4	62	58	4	--	13	25	--	--	--
5	71	30	--	41	4	2	11	4	8

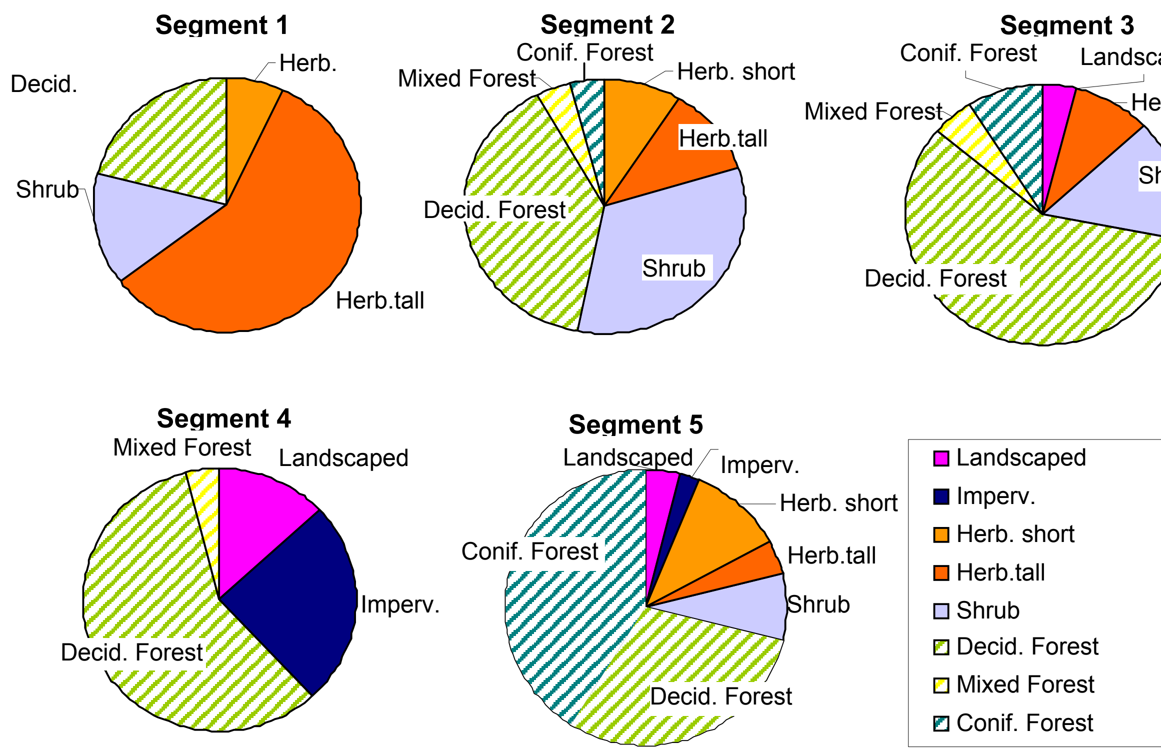

Figure 3. Riparian vegetation composition in Juanita Creek assessment segments.

Table 4. Invasive species present on Juanita Creek. More ++ indicate increasing general abundance. [1]

Segment	Himalayan Blackberry	Evergreen Blackberry	Japanese Knotweed	Field Bindweed	Bitter Nightshade	English Ivy	Reed Canary grass	Policeman's Helmet	Purple Loosestrife
1	++++		++	++	+				+
2	+++++		+	+++	++	+	+	+	
3	+++++	++++	+	+				+	+
4	++			+		+	+		
5	+++++			+	++	+	+		

Large Woody Debris

No segments of Juanita Creek contained enough LWD to fall within the published natural frequency ranges of 150 to 670 pieces/km (Murphy and Koski 1989, Ralph et al. 1994, *calculated from* Beechie and Sibley 1997). All segments were *one fifth* to *one tenth* of the low end of the range (Table 5).

- Segment 4 had the greatest LWD and large diameter LWD frequency (55 and 9 pieces/km, respectively).
- Segment 1 had the lowest LWD frequency (12 pieces/km).
- The frequency of large LWD pieces was well below "properly functioning conditions" (50 pieces/km) (NOAA 1996) in all segments (< 10 pieces/ km in all segments) (Table 5).

Table 5. LWD frequency in Juanita Creek. 150 pieces per kilometer is the low end of natural occurring frequency ranges (Murphy and Koski 1989, and Ralph et al. 1994, *calculated from* Beechie and Sibley 1997): all segments in Juanita Creek were below this range.

Segment	# LWD/ km	# >/= 0.5m diameter /km
1	12	2
2	29	5
3	29	0
4	55	9
5	23	5

Channel Morphology

Channel complexity and connectivity with the floodplain are reduced in Juanita Creek by streambank armoring (Figure 5). Mean segment bankfull width to depth ratios are generally not greater than 12 (Table 6), which suggests "properly functioning conditions," though without comparing current

[1] Scientific names of the invasive species are (in order listed, starting from the left): *Rubus discolor, Rubus lacinatus, Polygonum cuspidatum, Convolvulus arvensis, Solanum dulcamara, Hedera helix, Impatiens glandulifera, Lythrum salicaria.*

values to data from previous decades, it is difficult to determine whether the stream channel is unstable and enlarging or incising.

Bankfull Width to Depth Ratios

The bankfull width to depth ratios for Juanita Creek did not exceed 10, although the ratio for segment 3 was equal to 10. The ratios of the other segments ranged from 3 to 6 (Table 6).

Table 6. Bankfull width to depth (BFW:BFD) ratios for Juanita Creek segments. Values below 10 are suggested by the NMFS Matrix of Pathways and Indicators as indicative of "properly functioning conditions", between 10 and 12 the stream is "at risk", and above 12 conditions are not properly functioning.

Segment	BFW	BFW:BFD
1	5.6	6:1
2	5.3	3:1
3	6.3	10:1
4	5.0	4:1
5	6.9	6:1

Streambank Stability

Stable streambanks were the dominant condition in four of five segments of Juanita Creek. The percentage of streambank armoring was less than 20% in all segments, except segment 1 where 57% of the banks were armored. (Figure 5).

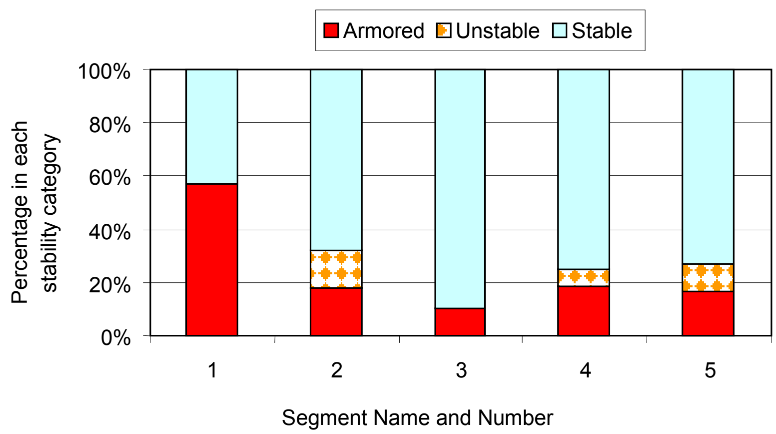

Figure 4. Streambank stability of Juanita Creek segments.

Sediment Quality

Sediment deposition from the creek is evident at the park at the mouth of the creek. Gravels suitable for salmon spawning were noted at two single assessed locations in segments 1 and 4. Three other site-specific notations relate the presence of fines and sand in segments 3 and 4. All summary comments described the presence of fines in the channel substrate (Table 7).

Table 7. Substrate quality field notes.

Segment	Distance from segment start (m)	Field Notes
1	203.6	Gravels, possibly suitable spawning habitat
1	Summary	Large unstable sediment load in segment
2	Summary	Many fines on stream bottom
3.C*	75	Nice pool, but loaded with fines
3	Summary	Lots of fines
4	4.8	Gravels, possibly suitable spawning habitat
4	101	Lots of sand and fines
4	111.8	Deep pool, fines dominant
4	Summary	Large amount of unstable fines and sands
5	Summary	Lots of fines

*The letter indicates the survey day; i.e., 3.C is the third day of surveying segment 3.

Pool Habitat

Pool to riffle ratios in Juanita Creek ranged from 2:1 to 1:2 (segment 2 and segments 4 and 5, respectively). Segments 1 and 3 had ratios of 1:1. Pool frequencies met suggested "properly functioning conditions" of 35/km (NOAA 1996) in every segment but segment 5 which had 28 pools /km. The percentage of riffle habitat in Juanita Creek was greater than or equal to 40% in four out of five segments (Figure 6). Mean pool depths were less than 0.5 m in all segments (Table 8). The distribution of the pool depths indicate that 69% of the pools were less than 0.5 m in depth and only 1% of the pools were greater than 1 m in depth (Figure 7).

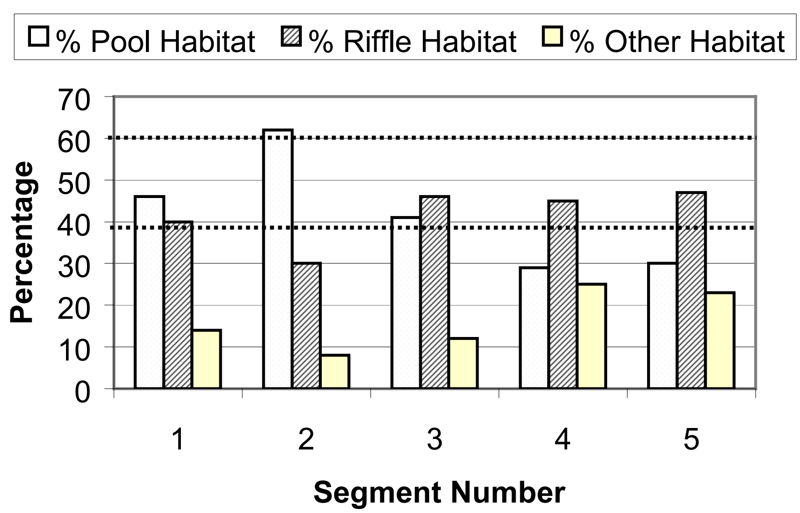

Figure 5. The percent habitat composition by area of Juanita Creek segments. Optimal habitat distribution is 1:1 pool to riffle ratio; the percentage of each should be between 40% and 60%. Glides are the predominant habitat classified as "other," however, runs are also categorized as other (Peterson et al. 1992).

Pool Quality Index

Although pool frequencies in four of the five segments met the NMFS' properly functioning conditions, the quality of the pools was generally poor. Pools received a higher Pool Quality Index

(PQI) rating if they were deep, large in relation to the size of the channel, and had additional features that would provide cover for fish such as woody debris, overhanging banks, or vegetation. The mean pool quality index was 2, which reflects low overall pool quality, and only two pools out of 68 were rated 5. Seventy-three percent of the pools assessed were rated 1 or 2 (Figure 8, Table 8).

Table 8. The average pool frequency and PQI of Juanita Creek segments. Pool quality index scale ranged from 1 to 5, with 5 being the highest pool quality (modified from Platts et al. 1983).

Segment	Pool frequency #/km	Average Pool Depth	Average Pool Quality Index
1	39	0.44	1
2	44	0.47	2
3	42	0.36	2
4	46	0.29	3
5	28	0.33	2

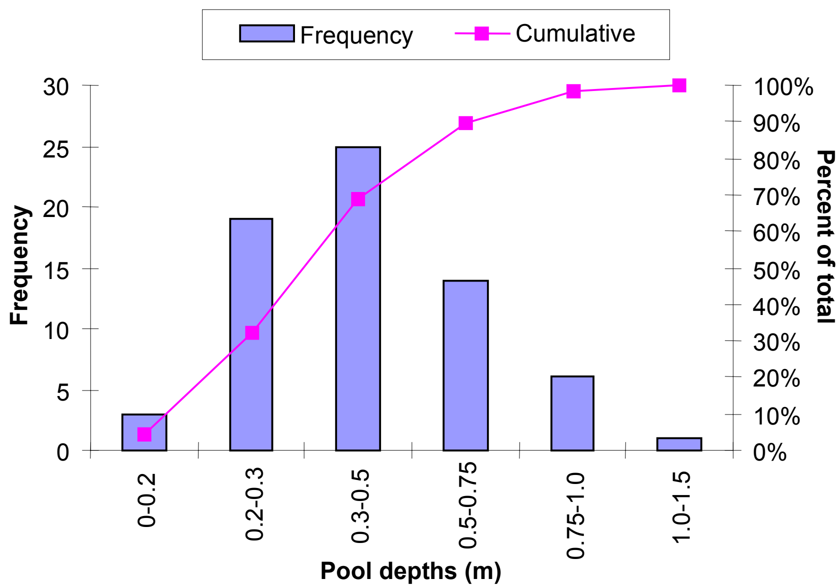

Figure 6. The distribution of pool depths in all assessed reaches of Juanita Creek. The cumulative distribution is shown by the line graph. Sixty-nine percent of the pools assessed were 0-0.5 meters deep.

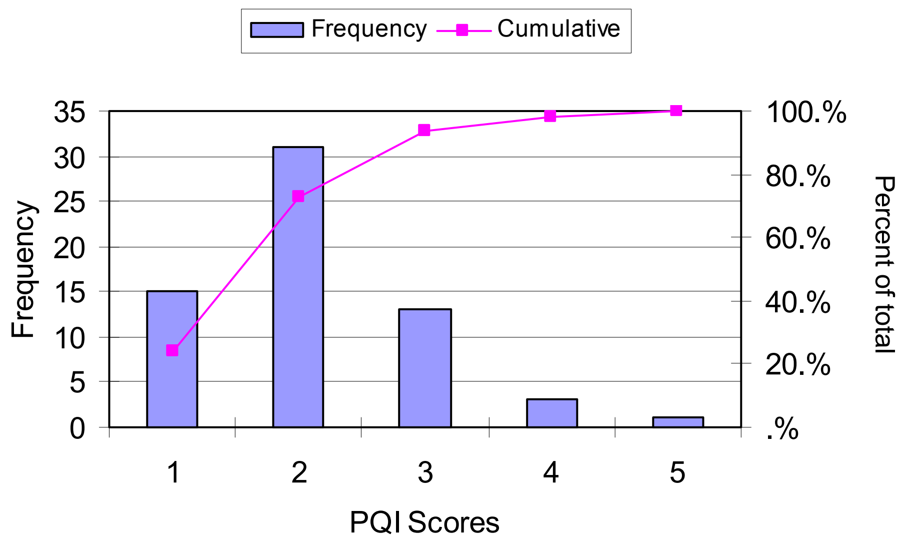

Figure 7. The distribution of PQI scores in all assessed reaches of Juanita Creek. The cumulative distribution is shown by the line graph. Seventy-three percent of the pools assessed were rated low (1 or 2).

Water Quality

Juanita Creek has been classified by the Department of Ecology as a Class AA (extraordinary) stream (Chapter 173-201A WAC). During this assessment, pH, conductivity, temperature, and dissolved oxygen were measured, and compared to Class AA water quality standards (Table 9). Mean values of temperature and pH met AA water quality standards, but conductivity did not and DO did only in segment 5 (Table 9).

Table 9. Water quality monitoring results from Juanita Creek. Numbers presented are means of duplicate samples. Surface water quality standards are listed in the right hand column (WAC 173-201A-030; HACH Company 2000).

Sample Number	1	2	3	4	5	Juanita Creek Mean	AA Water Quality Standards
Juanita Creek Seg.	1	2	2	3	3		
pH	7.9	7.7	7.8	7.3	8.1	7.8	6.5-8.5
Conductivity (µS/cm)	212	213	217	166	228	207	10-100
Temperature (^{o}C)	15.3	14.5	14.9	14.8	14.4	14.8	< 16*
DO (mg/L)	8.4	8.1	9.4	9.2	9.7	8.9	> 9.5

Data are available for comparison from King County Metro water quality monitoring studies on Juanita Creek. Data are available from 1986 to the present. Samples were obtained by Metro at the bridge on NE 128th Street east of 100th Avenue NE, which is located in segment 3 of this habitat assessment. Data from 1986 to 1992 (obtained during the same months as samples taken for this assessment) are shown in Table 10.

Table 10. October/November Metro water quality data from Juanita Creek (Quality of Local Lakes and Streams, 1987-1994). No data are available for October/November in 1989 and 1993.

Year	pH	Conductivity (µS/cm)	Temperature (°C)	DO (mg/L)
1986	7.7	195	9.5	11.1
1987	7.7	200	10.0	9.5
1988	7.6	195	12.0	10.8
1990	7.2	130	10.4	10.0
1991	7.7	206	12.6	9.3
1992	7.1	114	12.8	10.0

For comparison, Table 11 (below) contains data from samples taken upstream and downstream of the Metro sampling location, during the same months of the year.

Table 11. Water quality data from Juanita Creek, near Metro sampling locations (samples taken October/ November).

Location	pH	Conductivity (µS/cm)	Temperature (°C)	DO (mg/L)
NE 129th Pl.	7.3	166	14.8	9.2
NE 124th St.	7.8	217	14.9	7.2

Although the water quality data were only part of a preliminary sampling effort, the results suggest that a more complete water quality study may be warranted. Temperatures were generally higher, and dissolved oxygen was generally lower than measurements taken from 1986-1993. During the Metro study (1986-1993), October water temperature values ranged from 9.5°C –12.8°C. The sampling for this habitat assessment in October produced an average reading of 14.8°C. Stream temperatures between 13.9°C and 17.8°C indicate that stream habitat conditions may be “at riskS” of not properly functioning (NOAA 1996). All temperatures measured in this habitat assessment were in this “at risk” range. In addition, all but one of the dissolved oxygen levels during November of the Metro study were above 9.5 = mg/L (1991 at 9.3 mg/L), the minimum water quality standard for a Class AA stream. Four out of five samples taken for this habitat assessment were below this minimum level.

Biology

Salmonids were seen in all five segments. Although many fish were not identified to species, the following categories of aquatic biota were identified: salmonids, cutthroat trout, and crayfish. Table 12 presents specific notations on fish sightings.

Table 12. Biotic sightings in Juanita Creek.

Segment	Distance from segment start (m)	Field Notes
1	116.2	Crayfish sighted
1	141.5	Salmonids sighted
1	178.5	Salmonids sighted
1	196.2	Crayfish and cutthroat trout sighted
2	173.8	Approximately 20 juvenile salmonids sighted
2	Unavailable	Scattered salmonids seen in pools
3	115.4	Small salmonids sighted
3	Unavailable	Salmonids sighted
4	75.0	Juvenile salmonids sighted
5	25.0	Adult salmonids sighted (estimated five years)
5	113.0	Salmonids sighted
5	126.0	Salmonids/resident
5	239.0	Salmonids sighted
5	347.6	Juvenile salmonids sighted

Two possible habitat enhancement sites and four fish blockages were identified during the stream assessments (Table 13).

Table 13. Possible fish blockages and potential restoration sites on Juanita Creek

Segment	Distance from segment start (m)	Field Notes
2	100 (approx.)	Potential planting project near the Village Condominiums
4	150	Potential restoration site at Helen Keller Elementary
5	216.3	Dam is possible fish blockage, potential restoration site, 14206 – 110th Ave NE
5	312.1	Possible fish blockage
5	320	Possible fish blockage, LWD
5	Unavailable	Stormwater pond is possible fish blockage, in Highland Park, where creek flows under I-405

DISCUSSION

The cumulative impacts of land-use practices over the past century, including timber harvest, agriculture, and urbanization, have significantly modified the natural landscape characteristics of Juanita Creek basin, thereby altering many processes that maintain the natural structure and function of this aquatic ecosystems. Due to increased population, development has emerged as the most significant land-use in the basin today. The effects of watershed urbanization on aquatic resources are well documented and include extensive changes in basin hydrologic regime, channel morphology, and physiochemical water quality (Leopold 1968, Hammer 1972, Hollis 1975, Klein 1979, Arnold et al. 1982, Booth 1991, May et al. 1997, May and Horner 2000). The cumulative effects of these alterations on natural ecosystem structure and function have produced an in-stream habitat that is considerably different from that in which salmonids and other aquatic biota have evolved. In addition, development pressure has degraded riparian forests and wetlands, which are an integral component of stream ecosystems (Richey 1982, Steward 1983, Scott et al. 1986, Booth 1990, Booth and Reinelt 1993, May et al. 1997, Horner and May 1999). Parameters measured in this study suggest that urbanization has induced changes in hydrology, channel morphology, riparian integrity and instream habitat quality in the Juanita Creek basin.

Riparian Corridor

Riparian forest cover in the Juanita Creek basin is substantially diminished from pre-settlement conditions, although deciduous forest was the dominant vegetation in segments 3-5. The riparian vegetation has changed from the natural coniferous dominated forest cover to landscaped areas, grasses, shrubs, and various invasive species (Figure 4). Those areas where riparian forest still occurs are typically dominated by small diameter deciduous species including red alder, willow and big-leaf maple. The absence of mature trees, especially conifers (western red-cedar, western hemlock, Douglas-fir) in riparian areas reduces potential for LWD recruitment into streams (Table 2). Lack of LWD is also results in poor instream habitat quality and diversity (Sedell et al. 1984, Andrus et al. 1988, Murphy and Koski 1989, Beechie and Sibley 1997).

These assessments did not quantify stream buffer width. However, the Watershed Company (1998) determined that stream buffers along the mainstem varied from 10 to 50 feet in the developed areas. Current recommendations for buffer widths on streams are one site potential tree height, which is the average maximum height a climax tree may grow (approximately 170 ft in the PNW) (FEMAT 1992).

Channel Morphology

With increased surface water-dominated hydrology, streamflow tends to increase for a given storm event, and the duration of high-flow events also increases (Booth 1991). The resultant higher peak flows and more frequent bankfull, channel-altering events increase streambank erosion, bedload transport, and streambed scour (Leopold 1968). Urbanizing streams tend to “over-widen” or incise as a result of more frequent bankfull flows (Dunne and Leopold 1978). Mean BFW:BFD ratios of Juanita Creek were between 3 and 10 (Table 6), which are within the range of “properly functioning conditions” (< 10), and indicates that this stream is not “over-widening.” Armoring, however, was noted in the streambank stability data as well as the field notes, which may suggest that the stream may be prevented from over-widening by bank hardening, and may in fact be incising. A comparison of these data to historical data may reveal whether such changes in channel morphology are occurring.

Streambank Stability

Some streambank armoring to protect properties from damage by high storm flows is present in all segments (Figure 4), although the percentage of banks rated unstable or armored was low in all segments, except segment 1. Basin urbanization and loss of riparian vegetation are two factors that contribute to erosion and instability of streambanks (Booth 1991, Booth and Reinelt 1995, May et al. 1997). Riparian vegetation stabilizes streambanks and minimizes streambank erosion, the roots of riparian vegetation and LWD provide the bulk of this function (Bilby and Likens 1980). Besides vegetative cover, other stream corridor characteristics, such as soil-type and valley hillslope gradient, also contribute to the potential stability and current condition of the banks.

Large Woody Debris

The assessed Juanita Creek segments were severely depleted of LWD. All segments had LWD frequencies much lower that even the *low end* of published ranges for natural conditions in the PNW (range: 150-670 pieces/ km, (Ralph et al. 1994, Murphy and Koski 1989, calculated from Beechie and Sibley 1997). In general, small natural stream channels in the PNW tend to contain an abundance of LWD (Naiman and Bilby 1998). Large woody debris performs critical functions in forested lowland streams, including flow energy dissipation, streambank protection, streambed stabilization, sediment storage, and providing instream cover and habitat diversity (Keller and Swanson 1979, Bilby 1984, Harmon et al. 1986, Bisson et al. 1987, Gregory et al. 1991). Large woody debris in low-gradient pool-riffle or plane-bed streams like Juanita Creek has the greatest range of functional influences (Bilby and Ward 1989, 1991, Montgomery et al. 1995). The physically induced biological influences of LWD are substantial. Fish populations have been shown to decline rapidly following LWD removal (Bryant 1983, Hicks et al. 1991).

Numerous studies have found LWD recruitment potential depends heavily on riparian corridor quality and size (Murphy and Koski 1989, Van Sickle and Gregory 1990, Johnson and Ryba 1992, Fetherston et al. 1995, Rot et al. 2000). Although relatively high percentages of forested riparian reaches occurred in segments 3 through 5 of this assessment, natural levels of instream LWD was not present in these segments. This emphasizes that numerous mechanisms of LWD loss are operating in Juanita Creek, including transport downstream or out of the channel due to high storm flows, and removal by streamside residents. Large woody debris is typically quite low in PSL urban streams (May et al. 1997) and Juanita Creek is no exception.

Pool Habitat

The quantity of pool habitat in Juanita Creeks segments 1-4 meets NMFS' pool frequency standards (NOAA 1996), but the riparian vegetation does not provide an adequate source of LWD for recruitment to the stream. This results in an "at risk" rating from the Matrix of "properly functioning conditions." Segment 5 did not meet pool frequency standards or LWD recruitment standards and received a "not properly functioning" rating. The majority of pools in Juanita Creek were shallow and low quality, most likely due to cumulative effects of urbanization, such as changes in the natural hydrologic regime, reduced LWD recruitment. Pool frequency and depth has been shown to be directly proportional to LWD frequency, in addition, surface area and cover-quality are also directly related to LWD quantity and quality (Andrus et al. 1988, Robison and Beschta 1990, Ralph et al. 1994).

Field notes from these assessments observe occasional "nice gravels," but more frequently observe the presence of unstable sand and fines in the streambed (Table 7). In general, these data suggest that degradation of spawning gravels may be occurring. A more quantitative study of stream substrate could determine this more conclusively.

Invasive Species

Invasive species were found in the riparian corridors in all assessed segments of Juanita Creek (Table 4). In general, fragmentation and encroachment of the riparian corridor has provided pathways for invasive and exotic species, especially plants. Himalayan blackberry (*R. discolor*) and field bindweed (*C. arvensis)* are the most common invasive species along Juanita Creek, and dominate some of the riparian corridor. Of particular concern is the presence of Policeman's Helmet (*I. glandulifera*), which is a relatively new invasive in King County. In Britain, where the climate is similar to the Pacific Northwest, this plant is considered extremely invasive and is one of the "top 20" non-native weeds. A single plant can produce up to 800 seeds, which are viable for 18 months or more and can even germinate under water. Since the plant often grows along streams and ditches, seeds can be quickly spread downstream http://dnr.metrokc.gov/wlr/LANDS/Weeds/Mpatiens.htm While many of these invasive plants found in Juanita Creek may provide some beneficial functions to the stream (shade, detritus, bank stabilization, etc.), they are undesirable because, among other reasons, they are not a source of LWD and prevent native riparian species from becoming established in extensive areas.

Water Quality

Increased water temperatures and decreased dissolved oxygen levels are consistent with the effects of urbanization, and can be detrimental to salmonid and other aquatic life adapted to well oxygenated waters. Specific conductivity in urbanized streams and wetlands tends to be over 100 µS (May et al. 1997, Horner et al. 2001). Metro data (1986-1993) and from this study (2000) reveal conductivities greater than 150 µS in Juanita Creek, except in 1990 and 1992 when specific conductivities were 130 and 114, respectively. Elevated conductivity occurs in urbanized watersheds most likely because of ions from concrete and other materials associated with urbanization are leached into the groundwater (May et al. 1997). Continued water quality monitoring designed to capture changes in temperature and dissolved oxygen over the years would be beneficial to further determine habitat quality of Juanita Creek.

Biology

References that describe pre-development salmon runs in Juanita Creek are difficult to find. A 1948 report on spawning in Juanita Creek mentions that a few coho, kokanee, and cutthroat occurred in the stream. This is presented as declined productivity due to urbanization (Fisheries 1948). In a short Washington Department of Game report in 1968, Juanita Creek was described as a previously productive salmonid stream, but was then currently essentially non-productive (Ward 1968).

Results from other studies of Juanita Creek that were designed to evaluate fish presence help to detail current use of Juanita Creek by various fish species. According to a study recently conducted by The Watershed Company (*Kirkland's Streams, Wetlands and Wildlife Study*, July 1998), Juanita Creek supports both coho salmon and cutthroat trout. During this electrofishing study done from February 19th to March 17th, 1998, juvenile coho were captured as far upstream as King County's Edith Moulton Park (~RM 2.0), and adult cutthroat spawners[2] were seen even farther upstream. No fish of any kind were detected upstream of I-405 (~RM 2.5) (The Watershed Company 1998). The Washington Dept. of Fisheries Stream Catalog (1975) noted that coho and sockeye utilized the mainstem. Volunteer data from the SalmonWatcher program provides information about use of the stream by spawning salmon. Eight volunteer Salmon Watchers saw 16 sockeye and 19 kokanee in

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[2] These were identified as sea run cutthroat by the consultants. The criteria on which this identification was based is unknown.

the mainstem of Juanita creek in 2000 (Vanderhoof 2001b). The one volunteer who watched Juanita Creek in 1998 and 1999 saw no salmon (Vanderhoof 2001a).

Salmonids were observed in all of the segments assessed in Juanita Creek. The dates that the juvenile salmonids were seen in Juanita Creek are after sockeye and kokanee leave their natal streams, which suggests that these fish are either coho salmon or cutthroat trout.

CONCLUSIONS

The data from the habitat assessments described in this document indicate many segments of Juanita Creek lack the complex habitat structure that is important for sustaining a long-term, diverse salmonid population. Inadequate pool habitat (shallow pools with little cover) is likely a result of the cumulative effects of the interruption of numerous natural processes such as large woody debris recruitment, and local and basin-wide hydrologic buffering processes that interact to create these habitats.

Numerous activities associated with urbanization impact drainage basin hydrology (Booth 1991). Magnified peak flows and increased number of peak flows combined with the loss of LWD result increased erosion rates that cause increased channel widths and depths (Hammer 1972, Leopold 1973, in Booth 1991). Bankfull width to depth ratios of the assessed reaches of Juanita Creek do not stand alone to indicate increased erosion processes. Comparing channel dimension data from this assessment to data collected previously or in the future would indicate if the channel is widening or incising. However, other indicators of channel instability were observed. An instream detention pond at NE 124th Street on segment 2 has filled with sediment over a short period of time. Lack of wood and simplified habitat are also typical of streams impacted by urbanization (Booth 1991). Restoration and conservation planning efforts need to assess, and take into account the altered processes that create and maintain instream habitat structure in this basin.

Results from other studies in the PSL region demonstrate that retention of a wide, nearly continuous riparian buffer of native vegetation has greater and more flexible potential than other options to uphold biological integrity when development increases (Horner and May 1999). In newly developing areas riparian zones can be isolated from development. In developed landscapes, such as the Juanita Creek basin, riparian zones are often more lightly developed than upland areas, and could more easily be purchased and placed into protective status. Riparian buffer retention fits nicely with other objectives, like flood protection and provision of wildlife corridors and open space. Instream habitat would benefit most from securing and protecting existing high quality riparian buffers, enhancing or restoring degraded, but undeveloped areas, and protecting developed riparian zones and upgrading the integrity of the buffer by planting native species (especially conifers) and removing invasive plants.

General forest retention throughout watersheds has also been shown to offer important potential mitigation benefits (Horner and May 1999). This should be a high priority, especially for managing growth of undeveloped and lightly developed areas of the watershed. Forest retention combined with impervious surface limitation and riparian protection efforts would likely have the best results when pursued jointly.

The foundation of any effective environmental management effort is the formulation of goals developed with firm knowledge of what the ecosystem is capable of under varying circumstances, and what it needs to flourish at specified levels. Objectives should be stated in specific and measurable terms. This study should provide a solid baseline for future management decisions based on existing conditions in Juanita Creek.

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Appendix A:

Juanita Creek SSHIAP Segment and Assessment Reach Descriptions

Juanita Creek SSHIAP segments. Segments are contiguous; thus the start of one segment is where the previous segment ends.

Segment Number	Description	Length (km)	Length Surveyed (km)	Percent Surveyed	SSHIAP Gradient/ Confinement Category*
1	Mouth to 1st RR tributary (near 1st crossing of 120th)	.55	.204	37%	0-1 %, U
2	Ends just d.s. of 126th St. crossing.	0.85	.412	48	0-1 %, U
3	Ends at confluence with 2nd RR tributary (near 108th)	1.34	.453	34	1-2 %, U
4	Ends just d.s. of 141st.	.79	.215	27	1-2 %, U
5	To I-405? Is there still significant habitat above I-405?	1.34	.498	37	2-4 %, U
*Segment breaks coincide with SSHIAP breaks RR is river right d.s. is downstream U is unconfined.					

Assessment Reach Start and End locations

Segment	Date	Start location	End location	Meters surveyed
1	8/15/00	Juanita Beach Park Property	150 m upstream	150
2A	8/15/00	NE 122nd St.	End D.S. edge of NE 124th St.	75.8
2B	8/15/00	NE 124th St.	228.9 m upstream	228.9
3A	8/22/00	NE 129th Pl.	101st Lane NE	238
3B	8/16/00	Rd. Bridge @ 13145 132nd	75m NE of 132nd (at road bridge?)	215
4A	8/16/00	20 m d.s. footbridge which is 25 m d.s. 108th NE	108th NE-Edith Moulton Park	650
4B	8/16/00	Edith Moulton Park	152 m u.s.	152
5A	8/17/00	Culvert @ 111st NE	Footbridge @ 110 and 143rd	404
5B	8/17/00	50 m east of I-405	Footbridge @ 93.7m	93.7

Appendix B: Stream Habitat Assessment Methods

Stream Habitat Assessment Methods
July 28, 2000

Karen Fevold, Hans Berge, Elissa Ostergaard (WLRD) King County Water and Land Resources Division.

STREAM SEGMENTS

Reach breaks are determined by changes in gradient, channel confinement, and riparian landuse. If available use the TFW or SSHIAP segment boundaries. These breaks can be determined using GIS technology and confirmed in the field. Gradient categories are: <1%, 1-2%, 2-4%, 4-8%, and greater than 8-20% grade. Reach lengths should be 20 bankfull widths minimum length and 1200M maximum. Start and ends of reaches should be geo-referenced using GPS.

PREINVENTORY PREPARATION:

Determine length of the sample reach by calculating 25% of the survey reach length. At least twenty-five percent of a stream segment should be surveyed to adequately represent segment conditions (May 1996). The starting point of a survey reach must be chosen randomly.

FIELD METHODS

Habitat Inventory

Two persons, one with measurement and the other with note-taking tasks, conduct the surveys. Surveys will be conducted in an upstream direction during low flow conditions. The start and end of the survey reach will be marked with survey tape, so the GPS technician can identify and record the starting and ending locations. At the start of the survey hip chain string will be tied to known reference points; as the surveyors proceed upstream the locations and lengths of instream habitat units will be recorded. Habitat units will be identified as pools, riffles or other (see definitions below). Categories are kept simple to avoid compounding error due to observer differences. The lengths and widths of all habitat units will be recorded to the nearest 10 cm (4 inches). In pool habitats, maximum depth, and pool tail-crest depths will be recorded, as well as 4 thalweg depths. Pool Quality Index (PQI) (attached) will be determined for each pool using a rating system adopted from Platts et al. (1983). Pools receive a higher rating if they are deep, large in relation to the size of the channel and have additional features that provide cover for fish such as woody debris. Available discharge data will be noted on each survey day.

Habitat units are defined as:

Pool: Habitat units where scouring water has carved out a non-uniform depression in the channel bed or has been dammed. Slow water, with a width at least 1/2 of the wetted channel width and 20 cm minimum residual pool depth (Max. depth–pool tail-out depth). Surveyor should note if the pool is a dam pool instead of a scour pool. Backwater and side-channel pools should be included in the survey.

Riffle: Swiftly flowing, turbulent water with hydraulic jumps (white-water); some partially exposed substrate; substrate cobble and/or boulder dominated.

Other: Includes non-turbulent fast water habitat types such as **Glides**: wide, uniform channel volume, no thalweg, low to moderate water velocity, little surface agitation. Can appear pool like, but there is no significant scour depressions. Substrate is dominated by small materials. **Runs:** deep and fast with defined thalweg and little surface agitation. There may be flow obstructions in the form of boulders. Typical substrate is gravel, small cobble, cobble, small boulder, and boulders (definitions from Overton et al. 1997).

Large Woody Debris (LWD)

All pieces within the bankfull width and spanning the channel will be counted. Pieces with rootwads and/ or in debris jams will also be identified. LWD are defined as logs at least 2 meters (6 feet) long and at least 15 cm in diameter. The length and diameter of each qualifying piece of LWD will be measured and recorded in the habitat unit it occupies. The number of LWD pieces in a debris jam will be determined to the best of the surveyors ability and the volume of the DJ (including the small pieces) will be estimated from 3 dimensions: L x W x D.

REACH CHARACTERIZATION

Bankfull width and depth will be measured approximately every 25 m at riffles where the channel is relatively straight. At least 5 measurements will be taken per sample reach.
Locations of fences and other property boundary markers were identified by hip chain and noted on data sheets. Riparian vegetation type changes will be noted on the data sheets. Categories will be:

- Forested (> 20ft. in height), coniferous, mixed, or deciduous;
- Shrubs and/or vines (e.g. blackberries);
- Tall herbaceous (e.g. unmowed field, reed canary grass, etc.);
- Short herbaceous (e.g., mowed grass, pasture, etc.);
- Impervious (e.g. buildings, roads, asphalt, etc.);
- Residential landscaped (mowed lawn with ornamental shrubs/trees).

Presence and abundance (dominant or present) of invasive plant species are also noted (reed canary grass, blackberry, climbing nightshade, Japanese knotweed, etc. Use 4 letter abbreviations noted on the definition page.

BANK CONDITION

Bank stability will be determined at every riffle on each bank using the method described by Booth (1994). Categories are:

- **Stable**: vegetated or low bars to level of low flow, or stabilizing features (rootwads, vegetation, etc.)
- **Unstable**: imminent signs of erosion, or less than 50% vegetative cover.
- **Armored**: artificial bank protection of any kind (rip rap, wire mesh, etc.)

Stable banks show no signs of the following: Breakdown (clumps of bank are broken away and banks are exposed; slumping (banks have slipped down); tension cracking or fracture; vertical and eroding (the bank is mostly uncovered; i.e., less than 50% covered by perennial vegetation, roots, rocks of cobble size or larger and the bank angle is steeper than 80^{o}). (From Overton 1997).

SIDE CHANNELS, TRIBUTARIES, PIPES AND WETLANDS

- Location and size of pipes, and inflow or uptake will be noted. Tributaries and other side channels entering the stream will be mapped, and length and width of side channels will be measured.
- Locations of on-channel and nearby wetlands will also be noted and size will be estimated.
- Estimate numbers of fish, life-history stage (juvenile, adult), and species (if possible), and note in comments.
- Location of road and driveway crossings will be noted (these data should not be extrapolated beyond the survey reach).

REACH DESCRIPTION AND OTHER FEATURES

Other channel features such as fences crossing the stream, possible barriers to fish passage, culverts, areas of erosion or large sediment deposition, dominant substrate size, hillside seeps or springs, undercut banks, overhanging vegetation, etc. were noted. For each survey reach, the surveyor will write a brief narrative (about three to four sentences, longer if necessary) describing the quality of habitat, species and life history stages observed, and relative abundance of fish and wildlife, and any obvious problems or concerns such as point of discharge or withdrawal, and opportunity and/or need for protection or a restoration project.

PHOTOGRAPHS

Photographs depicting the general nature of each characterized reach will be taken as the surveyors proceed upstream. Film rolls will be numbered and roll numbers, exposure numbers, and a description of the photograph will be noted on in the comments section of the field data sheets for later cross-reference. A single roll (KC 12 exp. Roll) will be used for each survey reach.

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Pool Quality Index (PQI) for Puget Sound Lowland Streams (1st to 3rd Order)
(Modified from Platts et al., 1983)

Step	Description	PQI Score
1A	Maximum pool depth is >/ = to 1.0 m	**5**
1B	Maximum pool depth is < than 1.0 m…go to step 2	
2A	Pool wetted width spans most (>= 75%) of average wetted width…to step 3	
2B	Pool wetted width spans less than 75% of average wetted width…to step 5	
3A	Maximum pool depth < 0.5 m…to step 6	
3B	Maximum pool depth > 0.5 m…to step 4	
4A	Pool cover is abundant/ excellent	**4**
4B	Pool cover is fair to good	**3**
4C	Pool cover is poor	**2**
5A	Maximum pool depth is > 0.5 m, with good to excellent cover	**4**
5B	Maximum pool depth is > 0.5 m, with fair to poor cover	**3**
5C	Maximum pool depth is < 0.5 m, with good to excellent cover	**2**
5D	Maximum pool depth is < 0.5 m, with fair to poor cover	**1**
6A	Pool cover is excellent/abundant	**3**
6B	Pool cover is good to fair	**2**
6C	Pool cover is poor	**1**

Note: over conditions include LWD, over-hanging vegetation, undercut streambanks, and water surface agitation.

Stream Habitat Survey Data Sheet **King County DNRP, WLR Division**

Stream______________________________Segment____________________________Date____________
Start Location________________________End Location________________________Page_____of____
Start time___________________________End time_____________________
Write summary segment notes on reverse side of datasheet.
Water Temp__________________F C Air Temp_______________________ Weather____________
Crew____

Dist (m)	Habitat Unit		Pools								Wood		
	Type	Width	Type	Mean depths (4 #s)				Max Depth	Tail Depth	PQI	Type (L/RW/ DJ)	Diam	Length

Stream____________________________Segment___________________________Date____________

Measurements taken every 25 meters in straight riffles. Page______ of ________

Dist. (m)	Bankfull		Riparian Veg.		Bank Stability: **S/U/A**		Invasives	Comments: Tribs., Fish use (#'s, Y/N), dominant and sub-dominant substrate, pipes, etc. with meter distances
	Width	Depth	RB	LB	RB	LB		

Dis	**Exp.**	**Description of photo**

Stream Habitat Survey Instructions

King County DNR, Water and Land Resources Division

General Instructions: First page is for recording habitat units and biological observations (habitat unit identification). Second page is for measurements taken at riffles every 25 meters. When finished with the sample reach, write a description of the habitat that may not be included in the data sheet—include a general substrate description.

Habitat Type:
P - Slow water, scour depression in channel bed, length and width at least 1/2 the bankfull channel width.
R - Swiftly flowing, turbulent water; some partially exposed substrate; substrate cobble and/or boulder dominated;
O –Glide: Wide, uniform channel volume, low to moderate water velocity, little surface agitation. Run: deep and fast with defined thalweg and little surface agitation. Enter OR, OG
W - Riparian Wetland

LWD:
Measure all, minimum 2 m (6 ft) length & 15 cm (6 in) diam, no min for stumps.
Qty/#: If DJ, enumerate as 1, measure 3 dimensions: L x W x H.
Type: L=Log, RW = Root-wad, DJ=Debris jam
Form Pool? Has the log caused a pool to form? (yes or no)

Pools:
Type: D: dam pool, S: scour pool.
Tail Depth: Water depth @ hydraulic control at d/s end of pool

FW Mussels: Freshwater mussels - are they present? Indicate relative abundance.
Fish?: Note whether salmonids (any age class) are seen in habitat unit. Estimate abundance.

Substrate (sizes refer to intermediate diameter):
F - Fines <6 mm
G - Gravel 7- 64 mm
C - Cobble 64-256 mm
B - Boulder >256 mm

Bank Condition:
S - Stable – vegetated or low bars to level of low flow
U - Unstable – steep, raw banks only below or above bankfull level
A - Armored – artificial bank protection of any kind

Riparian Type:

FD, FC, FM = Forested deciduous, coniferous or mixed
SH = Shrubs or vines
HT = Herbaceous tall (unmowed/ungrazed)
HS = Herbaceous short (mowed/grazed)
IMP = impervious (roads, pavement, buildings)
LAND = Landscaped (mowed lawn, ornamental shrubs/trees)

Invasives: Dominant (D) = >20% cover on bank over reach. Species: (first two letters of genus & species):
RUDI / RULA Himalayan blackberry (*Rubus discolor*) or Evergreen blackberry (*Rubus laciniatus*)
SODA climbing nightshade (*Solanum dulcamara*)
ILHE English ivy (*Ilex hedera*)
PHAR reed canary grass (*Phalaris arundinacea*)
SPDO spirea/hardhack (*Spirea douglasii*)
POCU Japanese knotweed (*Polygonum cuspidatum*)
IRPS yellow flag iris (*Iris pseudacorus*)
COAR bindweed (morning glory) (*Convolvulus arvensis*)
LYSA - purple loosestrife (*Lythrum salicaria*)

Notes: Describe quality of habitat, species, life history stages, relative abundance of fish and wildlife, and any obvious problems or concerns such as point of discharge or withdrawal, potential fish passage barrier, and opportunity and/or need for protection or a restoration project.

Appendix C:

Matrix of Pathways and Indicators

WRIA 8 Reconnaissance Assessment Workshop Matrix

Matrix developed using "Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast, " NOAA, Sept. 15, 1996, Appendix II. For additional parameter definition, use Timber, Fish and Wildlife Monitori

PATHWAY	INDICATORS	Properly functioning	At risk	Not properly functioning
Water Quality:	Temperature	50-57° F[1]	57-60° (spawning) 57-64° (migration & Rearing)[2]	> 60° (spawning) > 64° (migration & Rearing)[2]
	Sediment/Turbidity	< 12% fines (<0.85mm) in gravel[3], turbidity low	12-17% (west-side)[3], 12-20% (east-side)[2], turbidity moderate	17% (west-side)[3], 20% (east-side)[2], fines at surface or depth in spawning habitat[2], turbidity high
	Chemical Contamination/ Nutrients	low levels of chemical contamination from agricultural, industrial, and other sources, no excess nutrients, no CWA 303d designated reaches[5]	moderate levels of chemical contamination from agricultural, industrial, and other sources, some excess nutrients, one CWA 303d designated reach[5]	high levels of chemical contamination from agricultural, industrial, and other sources, high levels of excess nutrients, more than one CWA 303d designated reach[5]
Habitat Access:	Physical Barriers	any man-made barriers present in watershed allow upstream and downstream fish passage at all flows	any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at base/low flows	any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at a range of flows
Habitat Elements:	Substrate	dominant substrate is gravel or cobble (interstitial spaces clear), or embeddedness <20%[3]	gravel and cobble is subdominant, or if dominant, embeddedness 20-30%[3]	bedrock, sand, silt, or small gravel dominant, or if gravel and cobble dominant, embeddedness >30%[2]

PATHWAY	INDICATORS	Properly functioning	At risk	Not properly functioning
Survey data, min. diameter used = 8", minimum length = 6.5ft.	Large Woody Debris	Coast: >80 pieces/mile (50/km) >24" (.6) diameter >50 ft. length[4]; East-side: >20 pieces/mile >12"diameter >35 ft. length[2];and adequate sources of woody debris recruitment in riparian areas	currently meets standards for properly functioning, but lacks potential sources from riparian areas of woody debris recruitment to maintain that standard	does not met standards for properly functioning and lacks potential large woody debris recruitment
Survey data: Juanita Creek average width = 20"	Pool Frequency channel width #pools/mile[6] 5 feet .. 184 10" .... 96 15" .... 70 20" .... 56 25" .... 47 50" .... 26 75" 23	meets pool frequency standards (left) and large woody debris recruitment standards for properly functioning habitat (above)	meets pool frequency standards but large woody debris recruitment inadequate to maintain pools over time	does not meet pool frequency standards
Survey data: PQI	Pool Quality	pools >1 meter deep (holding pools) with good cover and cool water[3], minor reduction of pool volume by fine sediment	few deeper pools (>1 meter) present or inadequate cover/temperature[3], moderate reduction of pool volume by fine sediment	no deep pools (>1 meter) and inadequate cover/temperature[3], major reduction of pool volume by fine sediment
	Off-Channel Habitat	backwaters with cover, and low energy off-channel areas (ponds, oxbows, etc.)[3]	some backwaters and high energy side channels[3]	few or no backwaters, no off-channel ponds[3]

PATHWAY	INDICATORS	Properly functioning	At risk	Not properly functioning
	Refugia (important remnant habitat for sensitive aquatic species)	habitat refugia exist and are adequately buffered (e.g., by intact riparian reserves); existing refugia are sufficient in size, number, and connectivity to maintain viable populations or sub-populations[7]	habitat refugia exist but are not adequately buffered (e.g., by intact riparian reserves); existing refugia are insufficient in size, number, and connectivity to maintain viable populations or sub-populations[7]	adequate habitat refugia do not exist[7]
Channel Condition & Dynamics: **Survey data**	Width/Depth Ration	<10[2, 4]	10-12 (we are unaware of any criteria to reference)	>12 (we are unaware of any criteria to reference)
Survey data	Streambank Condition	>90 % stable; i.e., on average, less than 10% of banks are actively eroding[2]	80-90% stable	<80% stable
	Floodplain Connectivity	off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession	reduced linkage of wetland, floodplains, and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession	severe reduction in hydrologic connectivity between off-channel, wetland, floodplain, and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly
Flow-Hydrology:	Change in Peak/Base Flows	watershed hydrograph indicates peak flow, base flow, and flow timing characteristics comparable to an undisturbed watershed of similar size, geology, and geography	some evidence of altered peak flow, baseflow, and/or flow timing relative to an undisturbed watershed of similar size, geology, and geography	pronounced changes in peak flow, baseflow, and/or flow timing relative to an undisturbed watershed of similar size, geology and geography

PATHWAY	INDICATORS	Properly functioning	At risk	Not properly functioning
	Increase in Drainage Network	zero or minimum increases in drainage network density due to roads[8, 9]	moderate increases in drainage network density due to roads (e.g., $= 5\%$)[8, 9]	significant increases in drainage network density due to roads (e.g., = 20-25%)[8, 9]
Watershed Conditions:	Road Density & Location	<2mi.mi[2, 11], no valley bottom roads	2-3- mi/mi^2, some valley bottom roads	>3 mi/mi^2, many valley bottom roads
	Disturbance History	<15% ECA (entire watershed) with no concentration of disturbance in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NWFP area (except AMAs), $\geq$15% retention of LSOG in watershed[10]	<15% ECA (entire watershed) but disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NWFP area (except AMAs), $\geq$ 15% retention of LSOG in watershed[10]	<15% ECA (entire watershed) but disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area; does not meet NWFP standard for LSOG retention
	Riparian Reserves	the riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all sub-watersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact), and/or for grazing impact	moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (=70-80% intact), and/or for grazing impacts: percent similarity of riparian	riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic species (<70% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural

Appendix D: Photographs of Assessed Reaches

Segment 1. Bank armoring and trampling was typical in this segment. Blackberry vines (Rubus lacinatus) were also abundant.

Segment 1. Culvert at NE 120th Street. Armoring typical of this segment.

Segment 2. This photo is taken looking downstream toward NE 124th Street. Note the large amount of sediment aggradation, and invasives in the riparian zone.

Segment 2. Residential encroachment on the riparian zone and channelized stream reaches were typical in this segment. A large piece of wood on the right bank was viewed as an eyesore and a hazard by adjacent property owners.

Segment 3. The stream margins are dominated by invasives at this site, blackberry vines on the right, and Japanese knotweed (Polygonum cuspidatum) on the left.

Segment 4. Little LWD, and compacted stream bank characterize this reach.

Segment 4. Large amount of sediment aggradation, scoured stream bank with LWD in the oversized stream channel may point to high discharges.

Segment 5. Residential encroachment on the riparian buffer can lead to increased access and alteration to the channel.

Segment 5. Riparian buffer appears to be well vegetated in this reach, and contains a considerable blackberry vine component.